Technical Review Paper

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VHF Antennas and Radiation Patterns

Introduction

Radio (RF) antennas form the basis of modern wireless communication technology. The radio frequency range (3 kHz – 300 GHz) is divided into a number of subcategories including Medium Frequency or MF (300 kHz – 3 MHz), High Frequency or HF (3 MHz – 30 MHz), and Very High Frequency or VHF (30 MHz – 300 MHz) [1]. The VHF range is important because it is used for various applications including analog TV broadcasting, communication with airplanes, military applications, amateur radio, and short distance communication. VHF is generally not suitable for long distance communication because it can be blocked by large obstructions such as mountains. Although VHF technology itself is not new, a lot of emphasis has been placed on its research due to the significant potential for cost and performance optimization. A couple commercially available VHF antennas as well as various cutting-edge VHF antenna configurations including the yagi-uda antenna array, the omnidirectional antenna, the broadband dipole antenna, and inkjet-printed fractal antennas will be introduced.

Commercial Technology

One available technology is the FG1480, an omnidirectional antenna that operates in the 148-152 MHz frequency range [2]. It could be bought for a cost of roughly $100 from a supplier such as digikey. This antenna is typically used for Low Power Wide Area Networks (LoRaWAN), which are commonly used in places with low cellular coverage, especially for IOT devices. The advantage of using an omnidirectional antenna is that the radiation intensity is roughly constant in all directions, allowing for communication with a device in any relative direction. However, the gain (the ratio of radiation intensity in a given direction to the radiation intensity when all the power accepted by the antenna is radiated isotropically) is relatively low for omnidirectional antennas due to their low directivity. The FG1480 has a gain of 0 dBi.

Another commercially available VHF antenna is the Omni DAS Antenna used in outdoor communication for fixed voice communications [3]. This antenna is also omnidirectional. Various models of this antenna are available with operating frequencies of 144 MHz to over 500 MHz. Each antenna model has roughly 12 MHz and unity gain.

Research and Development

Research and development of antennas in the VHF range continues to be performed due to their importance in applications such as telemetry and remote control[4]. Additionally, there is emphasis on improving their cost efficiency[5].

One antenna configuration that is currently being explored is the VHF yagi-uda antenna array [6]. The availability of electronically controlled phase shifters and switches has directed attention to the antenna array. The array consists of linear dipole elements arranged in rows. The configuration studied used 2 rows and 6 elements in each row, with an approximate spacing of 0.5-0.7λ and heights of 2.7 and 4.7 meters. The directivity provided by the optimized configuration was 19.29 dB at a spacing of 0.7λ where directivity is defined as the ratio of maximum radiation intensity to average radiation intensity. This VHF antenna is useful when detecting long range targets due the constructive interference from electromagnetic waves that reflect off a surface, such as the sea. On the other hand, destructive interference leads to nulls at lower elevation angles. Additionally, at this frequency, it is difficult to detect smaller airborne targets[7].

It is well known that simple wire antennas are inherently narrowband and have suitable radiation patterns only near their first resonance frequency[8]. In order to make them useful for broadband applications, modifications must be made. Possible modifications include embedding metamaterials along the antenna body, coating the wire antenna with a dielectric bead, or loading the antenna with RLC circuits and using non-Foster matching networks[9]. The integration of loads with the wire structure is a challenge, so most researchers have focused on the monopole configuration.

However, one research group designed and fabricated a low-cost broadband dipole antenna for the VHF/UHF range [9]. Their paper discussed the use of PCB technology and a cylindrical dielectric radome to design a low-cost super broadband loaded dipole antenna. The antenna had a voltage standing wave ratio (VSWR) < 3 and gain > -10 dBi in the frequency range of 30-1200 MHz.

A recent development in the design of VHF antennas is the use of Inkjet-printed 3D Hilbert-curve fractal antennas [5]. These antennas are designed by using an inkjet printer to deposit conductive ink on paper and folding the paper into boxes. The cubical box side lengths are .004λ and .002λ with resonant frequencies of 238 MHz and 147 MHz respectively. The resulting fractal patterns formed by the conductive ink lines give the antenna its radiation pattern. The gain observed for the two configurations studied were -8.46 dBi and -1.39 dBi respectively. The advantages of using paper as a substrate for the ink are that it is low cost, eco-friendly, and easily accessible. The advantage of using ink as a conductive material is that the deposition of ink does not require material removal and is therefore more cost-effective.

Conclusion

The antennas discussed here are still active areas of research. Due to both the great demand in modern applications as well as the seemingly infinite combinations of antenna types, geometries, matching networks, materials, and design and analysis methods, VHF antenna research continues to thrive today.

References

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